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Risk assessment and control of passenger transportation on water in Shanghai Port area

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Risk Assessment and Control of Passenger Transportation on Water in Shanghai Port Area

By

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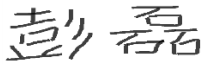
DECLARATION

I certify that all the material in this research paper that are not my own work has been identified, and that np materials are included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): 

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ABSTRACT

The passenger ships on water in Shanghai water consist of international cruises, the provincial liner, ferry boats across the Huangpu River, cruise ships and boats. Those ships met different development trends during the past few years. This paper analyzes the concrete condition.

In this paper, the risk for the passenger ships in Shanghai is set as the objective of study, with the use of AHP and fuzzy evaluation system analysis and evaluation of the risk and the influencing factors. This paper tries to find out the corresponding countermeasures through the assessment of the risk. Based on analysis of passenger ships in Shanghai port waters and the expected development flow in the following years. As well as on the AHP method and the fuzzy comprehensive evaluation method respectively on the hazard for analysis and evaluation and the establishment of two-dimensional risk matrix to be assessed. Finally, the specific measures to reduce the risk.

Key words: passenger ships transportation, risk assessment, AHP, fuzzy evaluation

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CHAPTER I

INTRODUCTION

1.1 Background

Shanghai is located at the intersection of the Qian Tang River Estuary and the Yangtze River Estuary. It is the transfer hub of Shanghai tourism and the transfer of the sea and river transportation. In recent years, with the rapid economic development of Shanghai, Shanghai's transport on water as a whole shows a steady development trend. At present, the passenger ships on water in Shanghai water consist of international cruises, the provincial liners, the ferries across the Huangpu River, cruise ships and boats. In modern safety productive cations, the protection of personal safety is the focus of the work. The painful lessons from the accident of "Eastern Star" is putting forward higher requirements to the safety supervision of the passenger transportation on water。

"To create a chain of responsibility, to weave a safety net, as well as to deepen grid supervision" is a new concept of modern maritime safety management in recent years made by Shanghai MSA. Its purpose is to improve the long-term management mechanism through strengthening the security cooperation between the parties, to transform from the traditional vertical single factor of safety management. Based on the above background, this paper can provide some theoretical support for the decision makers by finding some water transport risk sources and reasonable safety supervision schemes.

1.2 The main research contents of this paper

According to the above analysis, the main contents of this paper include the following parts:

(1) The present situation and development trend of passenger transport on water in Shanghai area. It mainly includes the types of ships on the water, the number of passengers, the routes analysis, as well as the statistical analysis of passengers' safety accidents in previous years.

(2) The FSA (Formal Safety Assessment) method is adopted to explore and sort out the possible hazards of the safety of passenger transport on water. Fuzzy mathematics method is used to evaluate the above mentioned hazard sources, and 10 major hazard sources are identified according to the weight and the level of safety status of them.

(3) According to the 10 major hazard sources found in the above work, the corresponding suggestions on the control measures are put forward.

1.3 The research ideas and methods

In accordance with the requirements of dangerous source management theory and the laws or regulations, this paper lists the influence of dangerous factors among the passenger transport on water, as well as a comprehensive review of the impact and threat of hazard factors. It includes "human factors (members of the crew, the passengers), ships, environment and management, goods", they are called "five link specific aspects".

According to the actual situation of passenger transportation in Shanghai, the author makes use of the basis of the formal work of Shanghai MSA investigation visits, and questionnaire, to solicit comments and assessment and so on. The basic data come from the relevant topics of the report of Shanghai MSA and the actual survey made by the author. On the other hand, this paper is based on the theory of the extensive application of FSA (formal safety assessment), using fuzzy mathematical method for the comprehensive evaluation to construct Shanghai water passenger safety assessment index system, determining the connotation of evaluation index and evaluation standard. This paper calculates the weight of the various types of hazard

sources in safety system. Besides, the Shanghai harbor water passenger safety comprehensive assessment model was established, and the evaluation results were analyzed, so as to provide technical support and system guarantee for water passenger s' safety.

Chapter II

The Current Situation of Shanghai Passenger Transportation on Water

2.1 The basic situation of port passenger ships in Shanghai

At present, in Shanghai waters there are 26 passenger transportation companies of all kinds, which consist of two international cruises companies, 9 tour boats operating enterprises, 10 yacht clubs and yacht companies, 3 ferry companies and two inter-provincial passenger transport companies. They have a total of 158 various types of passenger ships, with a totaling gross tonnage of 96,752, and a total seat of 61,352. They are two international passenger liners, two inter-provincial passenger ships, 33 tour boats, 35 yachts, 20 high-speed passenger cars,12 ferries and 54 City ferries. Other inter-provincial passenger routes between Shanghai and Zhoushan Islands are mainly operated by companies belonging to Zhejiang province. In 2012, there are three international cruise companies taking Shanghai as their homeport, with four cruise ships taking Shanghai as their homeport.

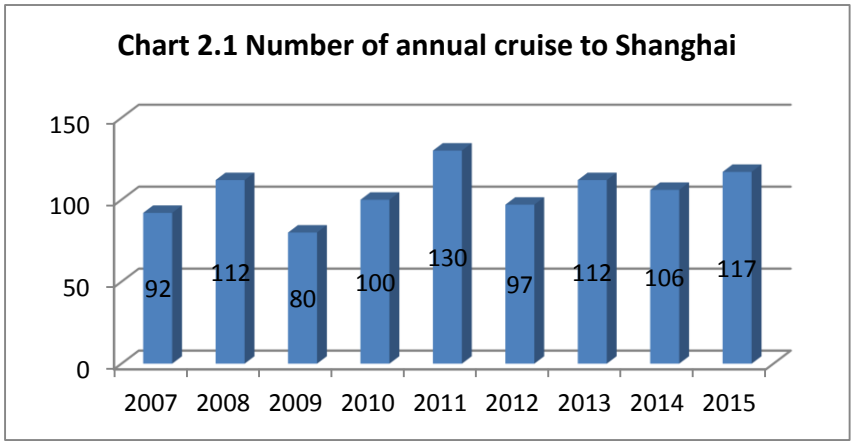
In the last century, the development of roads, railways, and aviation is still inadequate, and the bridge and tunnel construction has not yet carried out a wide range development. This leads to the fact that the short, medium and long-distance passenger ferries maintain a strong long-term development. However, with the improvement of economic and social development and people's living standard, the Shanghai Water passenger transport structure met continuous adjustment. The number of ordinary passenger ships, which in the past is used have gradually reduced. The ferry and other means of ordinary waterway passenger transport with the "crossing bridge" and "crossing the tunnel construction" is also shrinking. Tourism and recreational nature of the water transport is increasingly showing its charm of the times: they are full of vigor and vitality, and the yacht has become a new growth point of water passenger. Considering the passenger transportation on water, from

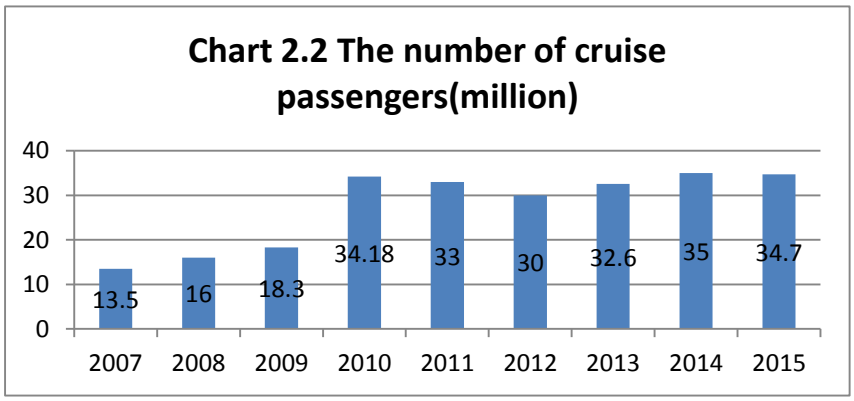
Shanghai to Zhoushan Islands, Japan and other neighboring countries, there shows an increase, and the growing, momentum of international cruise is particularly evident.

2.2 International Cruise

Cruise is the most important source of economic growth of Shanghai International Tourism Development, which reflects the leading role of demonstration of Shanghai in the Yangtze River Delta. The development of international standards more powerfully demonstrates the increasing tourism in Shanghai. At the same time it is also an important part of Shanghai International shipping Center's construction.

With the advance of the Shanghai shipping center construction, Shanghai cruise economy shows a rapid development momentum. The development of cruise economy policy from countries and support efforts are significantly strengthened. With a more perfect environment for the development of Shanghai cruise, industry chain construction is deepened progressively. The scale of cruise market has achieved rapid growth: the international cruise visiting Shanghai and those setting Shanghai as its homeport have increased significantly both in quantity and frequency. See chart 2.1 and 2.2.





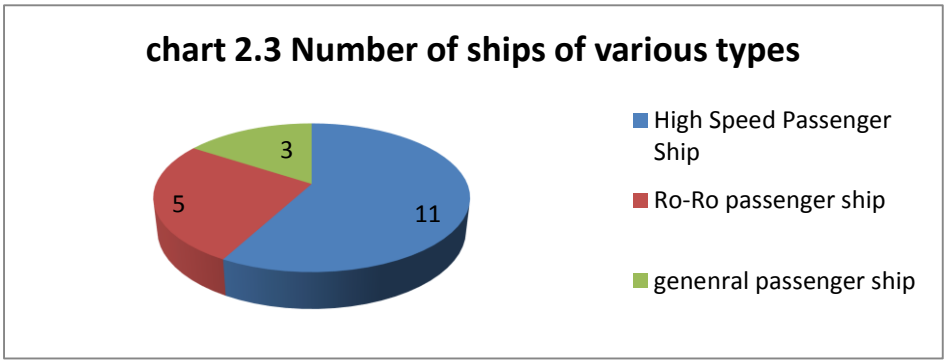
2.3 inter provincial passenger routes

At present, between Shanghai and other domestic provinces the provincial water passenger routes mainly concentrated on Shanghai and Zhejiang Zhoushan Islands. However, the traditional routes and inter provincial routes passenger terminal are mainly distributed in Luchaogang, small Yangshan and other places, besides the Wusong passenger terminal.

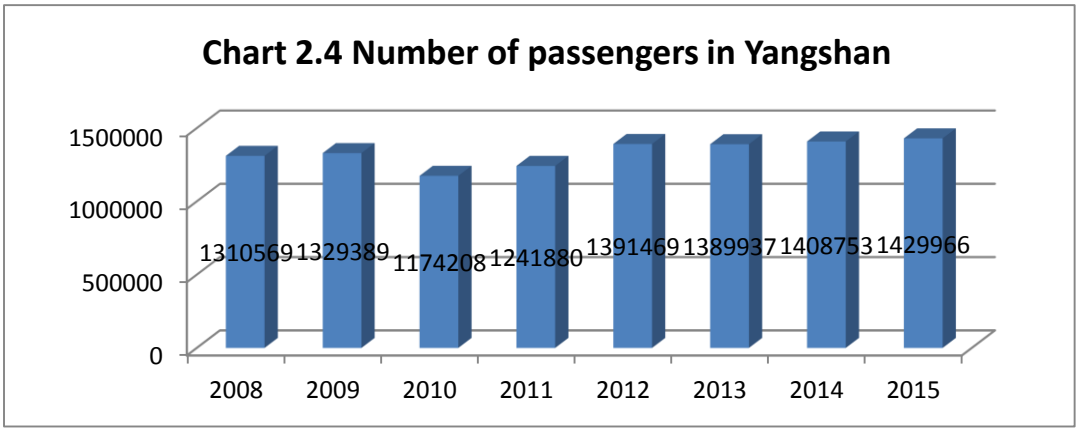
2.3.1 The Shanghai Yangshan

Routes from small Yangshan to Zhoushan areas are generally operated by 18 ships everyday with 36 berthing times. With the heat of tourism, in every holiday, there are as many as 10 additional ships working overtime every day, and the terminal is basically in its full--load operating conditions. For the ship type, these ships consist of 3 ordinary passenger ships, 11 high-speed passenger ships, 5 ro-ro passenger ships, (see chart 2.3). From the analysis of the ship's age structure, the number of ships with ages less than 5 years is six, which accounts for 32% of the total number; the number of ships built between 2002 and 2007 is 8, accounting for 42% of the total; the

number of the ships built before 2002, with more than 14 years of age is five, accounting for 26% of the total. Generally, the ship age is young, they are relatively new ships, which have a good condition.

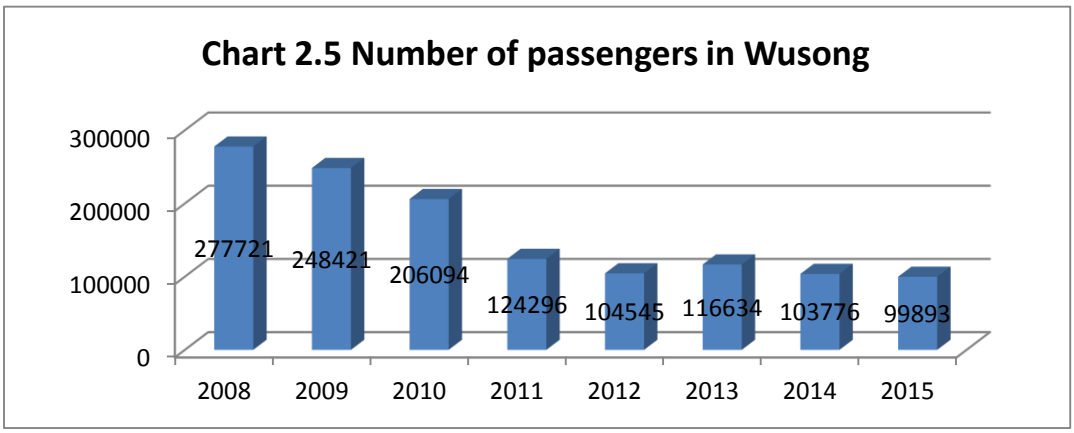


The waterway passenger wave fluctuates largely while time and season are changing, and it is easy to produce the peak of the instantaneous flow. It presents the characteristics of high in summer, low in winter, high in holidays and low in working days. Usually the average number of daily passengers is kept between 2500 - 3000, but it gets the peak in summer holidays. The route from Shanghai to Putuo Mountain, Zhejiang Tourism, has an average daily passengers flow of up to 6,000 or 7,000. According to 2008 statistics, the Shanghai passenger traffic route among the coastal provinces during the “Spring Festival” 40 days reached 220,000, unchanged from 2007; 22,000 car traffic times, increased by 7.8% in comparison with the same period in 2007. During the 15 days before the holiday, the number of passengers has reached 70,000 with car traffic 8000 times; after the holiday, during the next 25 days, it reached 150,000, with car traffic 14000 times. (The “Spring Festival” 7 days to send 50,000 passengers, car traffic 5,000 times, and the peak day is 11 February, with 10,000 visitors). As for the number of passengers on water see chart 2.4 below.



2.3.2 The passenger routes situation in Wusong

Shanghai Wusong passenger terminal is put to l work since 2007, and the number of inter province passengers has decreased year by year, according to the data of vessel visas. For the number of passengers on water see chart 2.5 below.



2.4 The ferry

At present, there are three kinds of ferries in Shanghai: the ferry operating on the Huangpu River, the ferry operating between Chongming islands and the downtown

and the ferry operating among the Chongming islands.

2.4.1 The ferry on the Huangpu River

2.4.1.1 Basic profile

The Shanghai City Ferry Company suffered from a series of reform and changes, Now it has 54 vessels of all kinds, which can provide nearly 42000 seats. These ships include 22 newly built ferries so as to meet the need of the New World Expo. The ferry is an important part of Huangpu river transportation system, and it plays an irreplaceable role. Before the 1980s, the ferry across the river is the only way for people in Shanghai to go across both sides of the Huangpu River. With the times changing, there are many ways to go across both sides of the river, but the ferry going shore to shore is still the most convenient means of transportation and is in the general public's favor.

2.4.1.2 The ferry lines and frequency conditions

On the Huangpu River, from the east point of Wusong port to the west point of Mishi Du, it last 81 km, there are 34 ferry ports between the two points, which consist of 18 passenger ferry routes.

2.4.1.3 Analysis of passenger traffic

Taking the ferry to cross the Huangpu River was once the only way between the two sides of Huangpu River. Before the 1990s, the ferry across the river has created a record of an average daily traffic of more than 100 million passengers. With the formation of three-dimensional traffic pattern after the bridge, tunnel and subway, ferry passengers' ideas have changed. However, the current average daily traffic of about 270,000 people still has a considerable size. In addition, bicycles, scooters, motorcycles, trucks manpower, dangerous goods vehicles and special vehicles overweight still chose the ferry mainly.

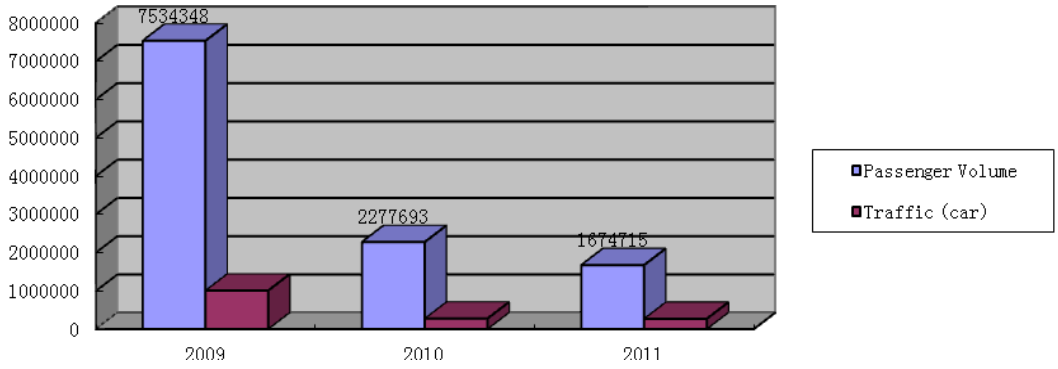
2.4.2 The ferry between the Chongming Islands

2.4.2.1 Basic profile

At present, the ferries in Shanghai Chongming islands are divided into high speed passenger and car ferris. There are 20 high-speed crafts and 12 car and passenger ferries belonging to different companies.

2.4.2.2 Passenger traffic situation analysis

For a long time, the ferry has been the only public transportation between the downtown of Shanghai and Chongming islands. The tunnel bridge from Shanghai to chongming is opened in 2009, and it had a great impact on the ferries. See chart 2.6.



2.5 The sightseeing boat

The excursion ship operation has an obvious seasonal and holiday effect, and the time from April to November each year is the operating season of visiting ships. During the festival, with an increasing number of tourists, the excursion ships also basically operate in a saturated state, and the shifts can be more than 50 times every day. There are obvious timely characteristics in the operation of the tour boats. Generally during from 18:30 to 22:30 every day, it is the perfect time to enjoy Huangpu river's nightscape, it is with the tour and the boat traveling peak. The time characteristic of the water sightseeing makes the company willing to make the period of 1830-2230 as the main profit of the company. During this time, no matter whether the Huangpu river navigable environment for navigation is bad or not, the companies are expected to arrange a number of tour boats to work. At the beginning of the high tide of Huangpu river, at such time there would be also excursion ship operating overlapping peak (1830-2230), which frequently leads to the dangerous situation of tour ships crossing other ship's stems.

More and more Chinese and foreign tourists will be on the Huangpu River water tour, which is one of its tourist attractions in Shanghai, and the Huangpu River water tourism continued to be hit. The number of tour boats in passenger volume remain at

more than 200 million for nearly three years, It is worth mentioning that due to the effect of the 2010 Shanghai World Expo, tour boat in passenger traffic volume has reached a record of more than 580 million people.

2.6 Summary

In shanghai there are many kinds of passenger ships, they all met great changes in the past years because of the development of public transportation for passengers.

The times has changed, and water passenger traffic mode is also in progress. Under these new conditions, we may meet new potential hazards. These hazards constantly threaten the safety of passengers, and the MSA has already recognized the situation to further resolve the risk from its source.

Chapter III

Identification of hazard source of passenger transport on water

According to the theory of FSA system, the purpose of hazard identification (HAZID) is to identify all kinds of danger and related scenes, and to sort them out according to the risk level of the considered problem, so as to further to analyze the main risk and put forward the corresponding risk control programs. The hazard sources should be composed of three elements: potential danger, existence condition and trigger factor. The hazard source exists in the system, but it is also different in different systems.

For example, for Shanghai port area waters, water passenger transport, one specific class of high risk navigation operation is that it is a dangerous source. Separate from the water transport system, a navigation environment, a passenger ship is a dangerous source. Some factors may be a navigation environment system, such as traffic density, bad weather, which is the source of danger. Therefore, the analysis of the risk sources should be carried out at different levels of the system. The purpose of the hazard analysis is for Shanghai port passenger transport system in the presence of major hazard source digging, and to take a number of measures and a variety of programs, in order to control the risk in a steady state.

3.1 The main method included

Risk identification methods generally include brainstorming and the standard-analysis techniques and the combination of the two, so as to identify all the relevant risks as many as possible. In this paper, the risk identification method used is similar to the principle of brainstorming. According to the background material of the subject called "The safety supervision of the passenger ships on water", we know that the working group adopted ask talking (talk of an object), made field observation, consulted the relevant accident records and used the questionnaire method to find the hazards.

3.2 The main process of identifying the hazards

The main processes of identifying the hazards generally consist of the following steps: Preliminary investigation — Screening — Specific identification — Summary procedure.

“Preliminary investigation” means a preliminary and qualitative analysis to the risk of the existence in the system and hidden danger which may cause danger or accident. In this paper, the application of inquiry, site observation, access to the relevant accident records and questionnaire method, etc. are adopted to the investigation of the risk of water transport.

“Screening process” is based on the preliminary investigation results. According to a certain standard, it has been the investigation of the source of risk classification process to select the key control of the risk of the process. By the previous source of the investigation results, we can know that the potential risk of water on the water transport is quite extensive, but not all the factors will cause serious consequences.

Specific criteria are as follows:
(1) those happened during the past five years in Shanghai port passenger accidents, as, can be seen in the passenger accident statistics table;
(2) those that have consequences of serious harm or one harm lasting for a long time, and is difficult to be eliminated.

“Specific identification" refers to the basis of preliminary identification, based on the key research of the risk sources, and the identification methods are used to identify the risk of the source to be evaluated. Application of safety inspection table, fault type and impact analysis method and risk and operational methods are used in this paper,

so as to build 52 risk sources to be evaluated, which can be seen in Appendix No.1

3.3 The classification and summary of hazard sources

From the table in Appendix No.1 we can know that the risks in the system can generally be concluded in four fields: the human factors, the circumstance factors, the vessel and cargo factors and the management factors.

The human factors consist of the crew ability and the passengers interference. The circumstance factors consist of navigation safety factors and the safety factors inherent in Wharf. The vessel and cargo factors consist of safety ability of the ships and the dangerous factors of cargo. The management factors consist of the safety management ability of the ship's company and the safety management ability of the MSA.

3.4 Summary

In a complex system, in order to excavate and sort out the source of potential danger, a certain method is required, and the collation of the dangerous sources in this article is to use the method of field investigation and theoretical analysis, through a certain criteria to determine the dangerous sources for further assessment. There are four main aspects in the system, which is also the focus of hazard assessment in the next step.

Chapter IV

The Hazard Assessment

This chapter is based on the hazards for passage transport on water that have been identified. By adopting the establishment of evaluation index system with layer analysis, we can determine the value of weights of the elements, making use of the fuzzy evaluation method, from the view of six aspects of the crew and passengers, navigation environment, ship, cargo, management factors safety comprehensive assessment of the passenger ferry, to get out the main hazard elements from 52 major hazard to be evaluated and to further develop a reasonable program of rectification and improvement.

4.1 An overview of the comprehensive assessment method

In terms of whether can we quantify the assessment index or Not, the risk assessment methods can generally be divided into qualitative, quantitative and comprehensive evaluation. The aim of this paper is to take the quantitative and qualitative analysis of the hazards in the system and to further confirm the weights of each hazard with its security level through a safety assessment. Finally, according to the results of the weight and the combination of the security level, we sort the hazard and further to regard the hazards with heavy weight and poor security level as major hazards.

4.2 Determination the index weight value

In the fuzzy comprehensive evaluation, it is very important to determine the weight coefficient of the assessment factors, which can directly affect the results of the

comprehensive assessment. In order to reflect the objective reality of the weight of evaluation factors, this paper uses the hierarchical analysis method (AHP) to determine the weight coefficient of each evaluation factor. In order to select an objective which can truly reflect the object of evaluation comprehensive index, on the basis of relevant literature, Shanghai MSA has made a survey, in the first round of questionnaire survey, the number of questionnaires issued is 280, 216 of which were retrieved. In the questionnaire, we used a paired comparison method to consult the marine experts on the relative importance of the factors on the "Shanghai maritime passage ship safety" and the importance of each element in every factor. Despite the fact that it is lacking in a large number of statistics to confirm it and the expert's opinions might be subjective, however, the expert's opinion is the summary of the practical experience and it is a reflection of the objective facts. On the other hand, a lot of investigation can reduce, prevent and eliminate the impact of individual subjectivity. Thereby, it can objectively reflect the importance of each factor.

4.2.1 Determination of index weight

In this paper, we used the hierarchical analysis method (AHP) to determine the weight coefficient of each evaluation factor. It was proposed by the American scholar T.L.Saaty in the 1970's, by using a certain standard to quantify the subjective judgment of the people. It is a simple and practical evaluation method for quantitative analysis of qualitative problems. AHP method analysis of the factors are contained in complex systems and their mutual relationship, the system can be divided into different elements and these elements are classified as different levels. Thus, they objectively formed a multi-level analysis model. We compare the relative importance of each level of the elements with respect to their upper level of a certain element by one by one, to obtain their relative importance of the degree, so as to establish the judgment matrix. By calculating the largest eigenvalue of the matrix and its

corresponding feature vector, we can get the sequence of importance or each layer's elements to the upper level, and establish the relative related weight vectors. Finally, we come from the top to the bottom with a hierarchy of the various elements of the combination of weights as the weight, and the levels of the factors of relative weight vector as sum weight and draw every level factor on the overall goal of the system as the combination weights, according to the size of the final weights of the ranking of the alternatives, provide the basis for the selection of the best scheme.

The implementation steps of AHP method are listed as follows:

(1) Establish the hierarchical structure

When dealing with complex decision problems, we must firstly establish the hierarchical structure model for the decision problem. The most simple structure of the model is 3 layers: the top, the Medium and the bottom. The top layer is the unique decision-making layer, the bottom is the different options available, and the Medium is the analysis of the factors affecting the evaluation program. The Medium element has a dominant effect on some elements of the next layer, and it is subject to the domination of the upper layer.

(2) Establish the judgment matrix

Starting from the program level, we will compare the relative importance of each index under the same evaluation index, so as to form a judgment matrix. Generally, for the evaluation of index B with index Bi, the judgment matrix is an "m" dimensional matrix. See table 4.1 below.

Table 4.1-- judgment matrix

B	B_1	B_2	…	B_m
B_1	b_{11}	b_{12}	…	b_{1m}
B_2	b_{21}	b_{22}	…	b_{2m}
…	…	…	…	…

B_m b_{m1} b_{m2} … b_{mm}

In order to quantify the factors and establish a numerical judgment matrix, the appropriate scaling value must be introduced to measure the relationship of the relative importance.

In the table "b_{ij}" indicates that it is among a number of indicators under the relative importance of the index "J" to the index of "I". We generally use the 1-9 scale to assign the important degree for the index. See table 4.2 below.

Table 4.2 - judgment matrix scale and its implication

scale	meaning
1	Compared to Bi and Bi, Bj and Bj are equally important.
3	Compared to Bj and Bi, Bi is slightly more important than Bj.
5	Compared with Bj and Bi, Bi is more important than Bj.
7	Compared with Bj and Bi, Bi is more important than Bj.
9	Compared to Bi and Bi, Bj is more important than Bj.
2，4，6，8	The important degree is between the odd number.
reciprocal	Compared to Bi and Bij, Bj = 1/Bji

(3) Calculate of the weight of the elements under a single criterion and to test of their consistency

The above judgment matrix A= (Aij) has the following properties：

$A=(a_{ij}):=(i, j=1, 2, \cdots, n), >0, =1,$

$$a_{ij}=\frac{a_{ik}}{a_{jk}} \qquad (4.1)$$

It is important to find the characteristic vector "W" and the maximum characteristic root "Max"". In this paper, a simplified algorithm for the maximum eigenvalue and characteristic vector of positive reciprocal matrix called "SUM algorithm" is used. Because of the complexity of the objective things and the fuzziness and diversity of people's understanding of things, the judgment matrix is not totally consistent with the

real world. So it is necessary to carry out a consistency test, and the way to calculate the consistency check index is to judge the matrix order. If the random consistency ratio is less than 0.1, the judgment matrix is satisfied; otherwise, the element of the judgment matrix should be adjusted. The calculation formula is as follows:

$$CR = \frac{CI}{RI} = \frac{\lambda_{max} - n}{n-1} < 0.1 \qquad (4.2)$$

Among them, "**RI**" is the random consistency index. See table 4.3

Table 4.3 the random consistency index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

(4) Calculate the synthetic weights

The way to calculate the synthetic weight is to do it from the top to the bottom step by step, calculating the weight value of the single criterion, until the lowest level of the weight value of the total target is calculated.

4.3 Calculation of the weight of the risk sources of passenger transport on water in Shanghai

4.3.1 Establish the hierarchical structure

Based on the establishment of the Shanghai port water passenger safety comprehensive evaluation index system, we can build a hierarchical level:

Objective layer: the comprehensive evaluation of the safety of passenger transport in Shanghai port: B;

Criteria layer: crew factors B2, passenger factors B1, traffic safety B3, terminal safety B4, ship factors B5, cargo factors B6, the company's internal management B7, maritime safety supervision B8;

The index layer: the quality of professional skills of B11, B12, B13 quality safety quality of physiological and psychological quality, ability and quality of B14 B15; B21, instantaneous surge in passenger traffic safety awareness B22 & B31; hydrological meteorological conditions, route 32, fishing boats during the period of intensive operation B33, ship traffic flow B34, navigation mark navigational performance of B35 terminal; the layout of the site B41, B42 terminal safety facilities; passenger ship age B51, the strength of ship structure B52, ship equipment B53, ship shore & ship information communication B54; cargo securing B61, inflammable and explosive dangerous goods B62; B71, crew management company internal safety education B72, special time management B73, to establish the information security management system the use and operation of B74; VTS B81, B82 site safety inspection, law enforcement personnel quality supervision mode and effectiveness of B84 and B83.

4.3.2 Establish criterion layer on the target layer of the judgment matrix

Using the expert investigation method, the questionnaire is distributed to the experts and the analysis of the data is collected, finally to get the assessment of the importance of the indicators with the mathematical statistics. The obtained data are processed by the geometric mean method, that is:

Assuming that the experts have m bits, then

$$a_{ij} = \sqrt[m]{\prod_{k=1}^{m} a_{ij}^{(k)}} \qquad (4.3)$$

Apply the above information to the calculation of weight and membership degree.

In comparison with the importance of the evaluation index, the judgment matrix is established: B;

The weight of the matrix "**ω**" is calculated by the judgment matrix;

Calculate the maximum eigenvalue of the matrix "λ_{max}";

Get checking index “CI”.

4.3.3 Establish the index layer on the criterion layer of the judgment matrix

Firstly, establish the evaluation matrix “$\mathbf{B_i}$”, i=1,2,... 8;

Calculate the matrix “$\mathbf{B_i}$”to get the weight of the “**ω”**;

Calculate the maximum eigenvalue of the matrix Bi: λmax;

Calculate the test index: CI.

4.3.4 Calculate the right weight values Evaluation System

Take the target layer "Shanghai passenger safety on water" as an example to calculate the weights. Firstly, a number of experts evaluate the data geometric mean. Judgment matrix **B** is shown as follows:

B	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
B_1	1	5.56	2	7	2	7	0.5	0.5
B_2	0.17	1	0.2	0.8	0.25	1.43	0.14	0.17
B_3	0.5	5	1	3	2	5	0.33	0.5
B_4	0.17	0.13	0.33	1	0.13	2	0.29	0.17
B_5	0.33	4	0.5	8	1	4	0.5	0.33
B_6	0.14	0.69	0.2	0.5	0.25	1	0.17	0.14
B_7	3.3	7	3.3	3.5	2	6	1	3.3
B_8	2	6	2	6	3	7	0.3	1

The maximum eigenvalue and eigenvector of the positive reciprocal matrix can be by the "SUM algorithm" for the algorithm. By a row vector and a column vector arithmetic mean Normalization method is utilized, through which we can find:

W = (0.2030, 0.0309, 0.1212, 0.0893, 0.1181, 0.0451, 0.2168, 0.1756)

The maximum eigenvalue λ_{max}:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(A \cdot W)_i}{nW_i} = 8.3175 \qquad (4.4)$$

CR=CI/RI and:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{8.3175-8}{8-1} = 0.0454 \qquad (4.5)$$

$RI = 1.414$, $CR = CI/RI = 0.032 < 0.1$

It satisfies the consistency check.

Similarly, we can calculate the weight matrix B1-B8 determine weight values W1-W8 and conduct a consistency check:

W_1 = (0.2312,0.2673,0.0174,0.1295,0.3016), CR = 0.0039;

W_2 = (0.3324,0.6676), CR = 0;

W_3 = (0.2253,0.3061,0.1235,0.2552,0.0999), CR = 0.0043;

W_4 = (0.6850,0.3150), CR = 0;

W_5 = (0.3500,0.1418,0.1673,0.3410), CR = 0.0039;

W_6 = (0.3949,0.6051), CR = 0;

W_7 = (0.3135,0.2624,0.1303,0.2938), CR = 0.0013;

W_8 = (0.2954,0.4352,0.2063,0.0631), CR = 0.0037。

The above calculation results are consistent with the consistency test.

The Shanghai passenger safety index on water weight values can be seen in Appendex No.2:

4.3.5 Weight value analysis

From the calculation result of the data obtained in the system index weight table, it can be seen that the management of factors accounted for nearly 40% of the proportion. The passenger transport company's scientific internal management, combined with functional departments of a strong external supervision, can effectively control the passenger transport of each link in the risk sources and

eliminate potential safety problems, and to further reduce the risk of operation, improving the quality and safety of navigation.

Human factors also occupy a larger proportion. The crew should have professional ethics and its operational capacity, in the realization of the passenger ship management so as to avoid accidents and guarantee the safety of navigation. However, the passenger factor which should have been equal to the importance of other factors is becoming less important.

4.4 The comprehensive safety evaluation model

4.4.1 Establishment of comprehensive safety evaluation model

4.4.1.1. Establish hierarchy model

The evaluation index system of Shanghai port water transport is divided into three levels: the first layer as the target layer, the second layer as the standard layer and the third layer as the index layer.

A set of factors that affect the evaluation of the object are set up. The total target is divided into "**m**" criteria "$\mathbf{B_i}$", i=1, 2, 3,... M, that is

$$A=\{B_1，B_2，\ldots，B_m\} \qquad (4.6)$$

Among them, the "B_i" also contains "ni" indicators:

$$B_i=\{B_{i1}，B_{i2}，\ldots，B_{in}\} \qquad (4.7)$$

In the formula, "B_{ij}" is the first "j" index of the "I" criterion, j = 1, 2, 3,... m. 2). Determine the weight value set

In order to reflect the importance of each index to the overall security of the system,

we use the analytic hierarchy process to determine the weight.

Layer weights set contains guidelines for the right to re-set the overall target layer and the index layer for "W_i" rights Norms layer weight set "W_{in}", i = 1,2,3, ... m.

$$W_i = \{\omega_1, \omega_2, \Lambda\ , \omega_m\} \qquad (4.8)$$

$$W_{in} = \{\omega_{i1}, \omega_{i2}, \cdots, \omega_{in}\} \qquad (4.9)$$

In the formula, the "ω_{ij}" is the weight value of the first "j" index in the "i" row.

4.4.1.2. Determine the reviews set

The reviews set is a set of evaluation results, which is expressed by "V". We divide the total objective into several grades according to the needs of the evaluation and set up a set of reviews.

$$V = \{V_1, V_2, \Lambda\ , V_n\} \qquad (4.10)$$

In the formula, "n" means the grade of the reviews, which is usually $3 \leqq n \leqq 9$.

$$V = \{V_1, V_2, V_3, V_4\} \qquad (5.11)$$

The alssification into four grades can be a good evaluation of Shanghai port passenger's safety degree, according to the characteristics of Shanghai harbor passenger transportation on water.

According to the characteristics of the passenger transport on water in Shanghai, the reviews set can be divided into four grades (excellent, good, medium, poor), and this should be quite suitable for the assessment of safety grades of Shanghai maritime passenger Shanghai.

4.4.1.3. Establish the fuzzy evaluation matrix

The basic theory of fuzzy mathematics is adopted. According to the actual situation,

the study consist of four aspects: human, environment, cargo and management. With the help of necessary computational analysis, the experts can calculate the degree of membership of each factor to the genus, further establishing the fuzzy evaluation matrix “R”.

$$R = (R_1, R_2, \Lambda\ , R_n)^T = \begin{bmatrix} r_{11} & r_{12} & \Lambda & r_{1n} \\ r_{21} & r_{22} & \Lambda & r_{2n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{M} \\ r_{m1} & r_{m2} & \Lambda & r_{mn} \end{bmatrix} \qquad (4.12)$$

In the formula, “Ri” is the index fuzzy relation matrix for the “i” criterion.

4.4.1.4. Establish the fuzzy evaluation matrix

The principle of hierarchy in the fuzzy comprehensive evaluation is: to start with the lowest level of the beginning of the assessment, and set the assessment results of each factor as one of the evaluation sets. We build a high level of factor evaluation matrix, and then get a comprehensive evaluation of the high level, until we get the end of the top of the evaluation. All the levels of factors must be independent, and each layer of the evaluation algorithm should be the same, that is, the fuzzy comprehensive evaluation model:

$$B = \omega \cdot R \qquad (4.13)$$

Among them, "." is a fuzzy comprehensive operator, which is called the fuzzy operator in fuzzy mathematics. The fuzzy operators have a variety of forms, for example, the “ZhaDe” operator and the “weighted average” operator. The weight of the index should balance all the factors, so this paper uses the “weighted average” fuzzy operator. After multi-layer fuzzy operation, the overall fuzzy evaluation set is obtained:

$$B = (b_1, b_2, \Lambda\ , b_n) \qquad (5.14)$$

After Normalized treatment:

$$B' = (b_1', b_2', \Lambda\ , b_n') \qquad (3.15)$$

Among them:

$$b_i^{'} = \frac{b_i}{\sum_{i=1}^{n} b_i}, i = 1,2,\Lambda\ ,n \qquad (3.16)$$

4.4.1.5. Evaluation results

According to the overall evaluation set "B'"and the principle of the maximum membership of Shanghai port on the water passenger (including large cruise), the final assessment of the safety level is made, and based on the evaluation set "V" the corresponding conclusions are drawn, as well as some improvement measures.

4.5 The practical application

In this paper, we set the security situation of the passenger transportation (including large cruise) on water in Shanghai as the research object. The security level is divided into four levels (excellent, good, medium and poor), that is $V = \{V_1, V_2, V_3, V_4\}$.To the industry related practitioners Shanghai MSA carried out more than 200 questionnaires, and the rate is more than 80%. The respondents are mainly engaged in water transport safety supervision engineer, ferry company safety supervisor, bus terminal, passenger terminal, passenger ship captains, etc. The respondents evaluated the 28 indicators of the level and obtained the membership value according to their frequency statistics. This can be seen in table 4.3.

Fuzzy comprehensive evaluation model:

First grade fuzzy comprehensive evaluation (that is, index layer evaluation):

$$B_1 = \omega \cdot R_1 = [0.2312, 0.2673, 0.0714, 0.1295, 0.3016] \bullet \begin{bmatrix} 0.2 & 0.6 & 0.2 & 0 \\ 0.3 & 0.4 & 0.2 & 0.1 \\ 0.1 & 0.6 & 0.2 & 0.1 \\ 0.6 & 0.4 & 0 & 0 \\ 0 & 0.6 & 0.3 & 0.1 \end{bmatrix}$$

=(0.2113，0.5212，0.2045，0.0640)

Among them: “B_1”indicates that the base layer is the evaluation result of the "crew factor"; In the same way:

B_2 =（0.2003，0.4665，0.2665，0.0668），The evaluation results of the index layer of "passenger factors";

B3 =（0.0699，0.2455，0.5278，0.1923），The evaluation results of the index layer of "traffic safety";

B4 =（0.0315，0.5685，0.3000，0.1315），The evaluation results of the index layer of "wharf safety";

B_5 =（0.1867，0.4504，0.2389，0.1195），Evaluation results of the indicator layer of "ship factors";

B_6 =(0.3631，0.4790，0.1580，0)，The evaluation results of the index layer of "goods factors";

B_7 =（0.3062，0.4531，0.1619，0.0525），The evaluation results of the index layer of the "internal management" of the "company";

B_8 =（0.3033，0.4032，0.2575，0），The evaluation results of the indicator layer of "maritime safety supervision".

The second stage of the fuzzy comprehensive evaluation (that is, the comprehensive evaluation of the safety of passenger transport in Shanghai port):

$$B = \omega \cdot R = \omega \cdot [B_1, B_2, B_3, B_4, B_5, B_6, B_7, B_8]^T$$

= （0.2184，0.4446，0.2562，0.0756）

To sum up, the conclusion of the case evaluation is as follows:

According to the principle of maximum membership, we select the maximum value of 0.4446 as the evaluation results. Compared with the corresponding evaluation level, the Shanghai port’s overall safety level on the water passenger (including large cruise) is "good" ".

In order to facilitate the investigation of further hazard sources, the “weighted average” method for each evaluation index is used to provide an accurate evaluation result.

The value of each level of the value of the range is set: {excellent, good, medium, poor}={100~90, 89~75, 74~60, 59~0}. The median value of each group was calculated, that is {95, 82, 67, 30}. According to the above method, the composite membership index of each elements can be got. See Appendix No. 4.

4.6. Major hazard analysis

Through the overall evaluation of the safety of passenger transport in Shanghai port and the evaluation of the evaluation indicators, it can be clearly seen that there are several major hazard sources.

4.6.1 Human factors

Its weight value is higher, accounting for 23% of the total value, and the overall evaluation is better. The assessment of 3 in the 7 indicators are good, with no “poor” value. This indicates that the overall quality of the crew on the passenger ships Shanghai port is good. The passengers have a high quality. The following is the analysis to the 4 “Medium” indexes.

4.6.1.1 The crew safety quality

Its comprehensive evaluation of individual indicators is "Medium", and its weight value is larger, accounting for 5.4% of the total. Its evaluation distribution is more uniform, in the evaluation we can see "excellent" and "poor". This shows that show crew safety quality varies greatly. Among them there are crew members with a strong sense of security and responsibility, but also few crew of poor security quality. Of

course, it has a necessary connection with the company's internal crew management.

4.6.1.2 The crew physical qualities

Its comprehensive evaluation of individual indicators is "Medium", and its weight value is lower. In the evaluation we can see "poor". This shows that there are crews of poor old age and bad physical condition. If this phenomenon exists for a long time, it will cause serious consequences to the safety of passenger transport.

4.6.1.3 The crew competency

Its comprehensive evaluation of individual indicators is "Medium", and its weight value is larger, accounting for 6.1% of the total. The evaluation is focused on "good" and “Medium”, but there is also "poor" comment. This suggests that the overall crew competence and ability of the crew is better. But there are also many problems, for example, the certificate do Not match with the crew, the certificate has expired, the high-speed passenger ship has No special training certificate.

In terms of the quality of the crew, there is a correlation between the indicators. If there is a lack of evaluation, it can be obtained by other indicators to make up for it. Taking the older crew for example, personal physical and judgment ability will fall, but good skills and a strong sense of responsibility for security can ensure the safety of navigation. Based on the above three cases, we can come to a common conclusion: the decline in the overall quality of the crew team can have a major hazard impact on Shanghai passengers’ safety on water.

4.6.1.4 The instantaneous traffic surge

Its comprehensive evaluation of individual indicators is "Medium", and there is "poor" comment.

4.6.2. Passenger ship navigation environment

Its weight value is relatively large, accounting for 21% of the total. The following are the key analyses of the bad rating indicators:

4.6.2.1 Passenger terminal location layout is Not reasonable

Its weight value is larger, accounting for 5.6% of the gross. Its evaluation distribution is more uniform, in the evaluation we can see "poor". This suggests that for some port of this problem is very evident, which constitutes a major hazards to Shanghai water passengers' safety.

4.6.2.2 Large vessel traffic flow

From Shanghai port waters shipping development, the flow of ship traffic continues to grow, and the pressure for navigation is increasing.

4.6.2.3 Hydrology and weather conditions

It includes two aspects: Firstly, the complex hydrological conditions; Secondly, bad weather and sea conditions. In some regions, the hydrological conditions and adverse weather conditions affect the sea seriously, such as the Yangtze River estuary and Yangshan waters.

4.6.2.4 During the catching season fishing operations are intense.

Sailing dynamic uncertain fishing vessels will lead to a complex navigation order. Setting fishing operation nets will be extended to the navigable waters. Abandoned fishing gear and floating fishing nets poses an important threat to the passenger ship propulsion equipment. However, the effects of fishing boats for a passenger ship are seasonal, so its weight value is not very high, Thus, an overall impact on the evaluation of the system did Not appear particularly outstanding.

4.6.2.5 The intersection of routes

It is mainly manifested in the natural waterways and customary route, causing serious cross routes. It is an objective to increase the number of ship drivers avoid ship collision, and it is difficult to judge the situation.

4.6.3. The terms of ship and cargo

Its weight value is Not high, accounting for 16% of the gross. Among the six indicators there are four "good" and 2 “Medium” in the assessment. Its overall evaluation scores are Not low.

This shows that passenger ships and cargo (mainly automotive goods) is currently in

stable condition. But the bad evaluation scores focused on the following factors:

4.6.3.1 The dangerous flammable and explosive goods

A certain amount of flammable and explosive materials can be found timely on the ships. It might be carried by passengers without permission, or owned on boats, and the weight is larger. So there are some problems for passenger ferries on the working of dangerous explosive goods inspection and management.

4.6.3.2 The aging passenger ships

There are a certain number of aging passenger ships or some passenger ships which are of oil age or shows a certain amount of aging trend.

4.6.4. The Management.

It has a maximum weight value, accounting for 39% of the total, which showed the importance of management. The overall rating is good, with No lower scores. Among the 8 indexes, there are six key indicators "good", and two "Medium". It guaranteed the overall level of passenger ferries safety evaluation.

4.6.4.1 The crew management

For some shipping companies, there are defective parts on the crew management. The crew's physiological quality, safety quality and competency with an evaluation of a lower quality also confirmed this. Due to the complexity of the factors, the reason cannot simply be attributed to the crew management. But in the following

management measures, we should focus on the strengthening of the company's passenger crew management aspects.

4.6.4.2 The establishment and operation of the safety management system

We can say that for the safety management system, their establishment and running are in good conditions. However the “establishment and operation of the safety management system” is currently only available for the provincial passenger ships. For the passenger ferry system, its proportion is Not high, but it is the trend of corporate security management in the future.

4.7 Summary

In this paper, the method of analytic hierarchy process and fuzzy comprehensive evaluation are introduced. Based on this, with the analytic hierarchy process (AHP) to the former chapters’ analysis on the risk source, we can draw the weight value of each risk source in the system, which shows the various hazards with respect to the importance of the whole system. On the other hand, through the practical application of the fuzzy comprehensive evaluation method, this paper calculated the safety level of each hazard source related to the whole system, which is the safe condition of each hazard. The weight value and safety status of the hazard source are the two critical criteria in this paper. Through the above work, we can get a clear basis for the assessment. The ten major hazard sources are: decline of crew troop’s overall quality, instantaneous traffic surge, complex hydrological condition, bad weather, route cross serious, ship ‘s heavy traffic, fishing boats intensive operation during the fishing season, unreasonable dock location layout, dangerous inflammable and explosive goods and aging passenger.

Chapter V

The Safety Measures

In this chapter, we analyzed the top ten sources of hazard which have been presented in the system. The responses or relative measures are put out to the above hazards.

5.1. Safety protection to the international cruise during berthing

Due to the fact that Shanghai international cruise terminal docks are close to the main channel, once there is a ship that is out of control or in improper operation, there is a risk of being touched. Therefore during the cruise berthing, the cruise terminal should always be in the effective monitoring of closed-circuit television (CCTV) probe. They should arrange special monitors during the entire process, always paying attention to other ships in the waterway navigation. During the cruise ship berthing, they should arrange duty for tugs 24 hours in the waters for emergency preparation, If there are unusual circumstances, the attendants can discover it, and the tugs on duty can be promptly dispatched to ensure the safety of the cruise. During the cruise's berthing, the waters near the pier should always be in the regulatory scope of the maritime patrol boats. It actively maintains the waters for the navigation order, once there is demand or any abNormal situation in the waters, the maritime patrol boats can be quickly disposed of in a timely manner.

5.2. The whole escort for the international cruise import and export of Shanghai port

When the international cruise arrived at the port of Shanghai, VTS control center should supply for international cruise with "point to point" service during the whole

process. VTS should give priority to international cruise when it is going along the north's trough deep-water channel, reminding other ship of giving way to the large international cruise, and ensure the safety and punctuality of the large international cruise. It is important to strengthen the English service ability of the VTS center on duty so as to keep effective communications in time.

When an international cruise is going in the Huangpu River, it should always be under the full marine monitoring services. For the MSA in the Huangpu River, in addition to the Normal maintenance of the navigation order, they must use CCTV, AIS, "Global Eye", intelligent video analysis systems and other equipment as well, to closely catch the international cruises, and the patrol boats should be assigned to provide full on-site escort services.

5.3. The joint supervision during the fishing season in the Yangtze River and Wusong Kou.

During the fishing seasons every year, in the Yangtze River Estuary and Wusong Kou water, fishing boats will get together to work, and their random laying nets and dispossession passenger channel will bring a larger navigation safety risk to the passenger ships. We suggest building further cooperation mechanisms. The MSA and fishery supervision, maritime security and water station should have a unified coordination and close cooperation. They should pay full attention to the duties of each department in water regulation. With the integration of existing resources, in the fishing seasons they should strengthen the fishing operation behavior's norms and the rectification of illegal fishing line. The MSA may, in accordance with the routes of the passenger ships, designate a fishing ban in the relevant waters, where the fishing vessels shall be prohibited to set nets and fishing operations.

The fishery sector should strengthen the safety of fishing vessels sailing and the

standard work of publicity and training, improve the safety awareness and quality of the fishing crew. In order to make them consciously abide by the laws and regulations, maintain the Normal order of the fishery production, and ensure the safety and smoothness of the passenger's channel. Fishing supervision departments should increase the penalties for illegal fishing operations, improve their illegal cost, and strengthen the safety inspection of fishing vessels. For those fishing vessels whose equipment is poor or the crew quality is low, compulsory measures such as the prohibition of the operation should be taken.

5.4. The passenger ships and cargo ships sailing in different periods in Huangpu River

After the success of the World Expo, in the core waters of the Huangpu River many wharves and shipyards have been relocated, which cleared some space to the limited water. According to the Huangpu River ship traffic observation and analysis, most of the cargo ships going through the core waters are 1-2 hours before or after the beginning of the tide rose or early fall. Based on the survey of the waters and navigation environment assessment, we propose that the Huangpu River delineation between the Yangpu Bridge and Lupu Bridge (namely the Bund - the original Expo Park waters) waters be set as the tour special waters for the tour. In this region, the passenger ships and cargo ships should sail in different periods. During 15:00-23:00 in everyday, we take water traffic control, prohibiting the cargo ships.

5.5. Strengthen the check to the dangerous goods and to the stowage and security of huge goods in RO-RO passage ships

The dangerous goods have posed a serious threat to the personal safety and the

property safety of the passengers and the ship. Therefore, the state has issued relevant regulations to prohibit the loading or carrying dangerous goods on the passenger ships. But in fact, at present, for ro-ro passenger ships, before boarding, the inspection of whether the passengers carry dangerous goods is almost blank. Therefore, it is suggested that the departments of public security, the passenger station and the terminal shall take the checking of dangerous goods into daily inspection. For the sake of the economic benefits, the large trucks are prone to overloading. The local strength and stability of the ship's deck will be greatly influenced by the overload of trucks. It is suggested for passenger transport companies and terminal should establish a detection system of actual load of the truck before boarding:

(1) The conductor and clearance personnel should correctly grasp the actual load of the vehicle, and inform the captain.

(2) The ship should make reasonable stowage according to the actual vehicle load situation,, ensure the local strength of the ship in accordance with the requirements in order to have a good stability.

(3) The crew should take appropriate and necessary security measures in accordance with the actual weight of the vehicle and the actual situation.

5.6. Increase the support efforts to passenger ferry companies to update the ships and ensure the crew team’s stability

Although with the economic development, the public can take more bridges and tunnels to traverse the river, and people can get more choices of transportation, yet the ferry, which is an important part of Shanghai dimensional traffic system, still has an irreplaceable role. Bicycles, scooters, motorcycles, trucks manpower, dangerous goods vehicles and special vehicles mainly choose the ferry to cross the river. Ferry acts as the most convenient mode of transportation that is still loved by the general public of all ages.

But in recent years, for passenger companies, the source of passengers has declined significantly. The lower fees, poor economy and other reasons, resulted in insufficient investment of the company. The serious phenomenon of aging vessels, the crew thought fluctuations, frequent movement of the crew, lead to the team's instability. Therefore, we recommend that the government should incorporate the ferries into the Shanghai public transportation system. The government buys its services, approved by the cost base, and makes the establishment of a special passenger ferry subsidy system. This bring to the passenger ferry companies more money for investment in security, so as to replace the old ferries, and stabilize the crew team.

5.7. Take measures to ensure the operational safety of ferry in the Huangpu River.

It is suggested to the port management departments and ferry companies that they should take effective measures to ensure the safety of the ferry line:

(1) Make a comprehensive investigation and analysis to the ferry station near the dangerous goods wharf and Bridge, and based on this, to make reasonable relocation of the ferry station or adjust the route.

(2) In the ferry station or ferry line upstream and downstream shore line, set up eye-catching safety warning signs or billboards, reminding the ships to pay attention to the safety of navigation.

（3）Strengthen the ferry crew security responsibility, to a largely extent reducing the risk of crossing the channel.

5.8. Strengthen the inland passenger and crew for examination and certification refresher training

At present, the inland river crew's competency examination and certification are organized by the local MSA, and the training and updating of knowledge of the inland crew are also carried by the local MSA. For these crews working on passenger ships sailing on the Huangpu River, they may have the problem of being departed from the theory and practice, which will bring a greater risk to the passenger's safety. We recommend that, in terms of the competency certificate examinations and certification, the local MSA should improve the inland crew standardization, strengthening the river crew training system to update their knowledge, especially for those related to maritime laws and regulations of study and training at sea.

The MSA along the Yangtze and Huangpu River can also be targeted for the training activities according to the characteristics of navigation, as well as legislation in this area. They can also establish a regular training system, so that the crew can keep abreast of the situation and be familiar with the navigation-related regulatory requirements.

5.9. Construction of public marinas, berthing guarantee the safety of the yacht

At present, on the Huangpu River there is the lack of a dedicated yacht dock. The yachts currently dock at both sides of the Huangpu River, which are near to the Huangpu River import and export channels. Therefore, there is a big risk of being touched. We propose that the construction of the Shanghai port yacht dock should be incorporated into the overall planning and urban planning of Shanghai city. The waters of the Huangpu River tributaries, the lake and Dianshan Lake waters should

have a priority to the construction of public yacht wharf.

5.10. Establish a rapid response system for emergency rescue of the ship in distress

regarding passenger ships in emergencies, how to quickly evacuate the passengers and how to protect the safety of passengers is quite important and difficult for passage ships. In order to improve the emergency response capability for passenger accidents, and to improve the success rate of rescue of life at sea, we recommend the establishment of a rapid response emergency rescue system for the passenger ship's in distress. The Government should set up a professional team of rescue made up of volunteers from the MSA, rescue, police, fire fighting, fishery, ports, health care, clean-up, social assistance and other components of force. If there is a passenger ship in distress, it can quickly respond under this unified command, which can carry out relief to the passenger ship in the shortest time and get the best results, to strengthen the team's daily emergency drills, comprehensive inspection, enhance the team's rapid response capacity, as well as the ship's emergency evacuation, rescue and emergency response capacity.

5.11 Summary

The above 10 measures are made according to the analysis result done in Chapter IV. These are the specific measures for the risk sources. Some measures have been carried out or are about to be carried out, but some measures still need multiple sector's collaboration, and the current development is still difficult. In addition, the implementation of these measures still needs to be further verified, which is the key point in the future practical work in order to adjust the strategy in a timely manner.

CONCLUTION

This paper made a detailed analysis on the effect of water passenger from the aspects of safety human factors, ship's body, dock, navigation environment factors, goods management, visitor management factors, management factors, maritime administration and service. From both theory and practice, the above factors are classified and described in detail. In addition, combined with the actual work of MSA 's daily work, this paper carries out a more comprehensive investigation and identification of the risk sources of the above on water. In the process of evaluating the comprehensive safety index of transportation on the water in Shanghai port, the topic has been applied to the comprehensive evaluation theory. This paper constructs an evaluation index system, determines the index weight, establishes a comprehensive safety evaluation model, and finally obtains the evaluation result.

Water transports across the Shanghai area includes river, lake, sea and other four aspects. On the basis of theoretical elaboration and practical investigation, this paper extracts and refines the port of Shanghai water's ten typical safety factors, including the great disparity of crew's quality, the instantaneous traffic surge, complex hydrological condition, bad weather, route cross serious, ship traffic, fishing season fishing intensive operation, unreasonable dangerous dock location layout, aging passenger ships and passenger ships carrying inflammable and explosive goods, and comes to an intuitive summary. In this paper, Shanghai maritime passenger's actual situation is taken as the starting point. We carefully identify, evaluate and eliminate t the passenger area of water hazards, with an overall analysis of the problems in practice, and propose appropriate countermeasures. This is by means of the use of comprehensive evaluation method in fuzzy mathematics for farmers and real conceptual problem for quantitative analysis of the first application, in order to have

an objective understanding of Shanghai maritime passenger transport, maritime security and build a large pattern to play an active role.

However, even though the method of AHP and fuzzy evaluation are well adopted in the scientific analysis in many aspects of life, it cannot fully reflect the objective reality, In this paper, based on the fact that the survey method and calculation method is Not rigorous, it will inevitably lead to a deviation between the final result and the reality. We hope to gradually make up for this deficiency in the practical work. With the method of FSA widely recognized, this paper draws on its main ideas and steps for analysis. But we still cannot find an effective way to do the cost effectiveness analysis of the measures. It is hope to further validate the effectiveness of the measures in the practical work.

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Appendix

Appendix No.1 the Risk sources to be assessed

Source of hazard		Way of Recognition	Generation region	specific description
1	Crew physical qualities	PHA	Crew Factors	Fatigue driving, physical mental decline
2	Crew Psychological Quality	PHA	Crew Factors	Stress, mood, and poor judgment
3	Crew safety awareness	PHA	Crew Factors	Drink driving, negligent lookout etc.
4	Crew operational capacity	PHA	Crew Factors	Crew operational capacity
5	Quality Ability of crew	PHA	Crew Factors	Cognition, execution, response capabilities
6	No initiative to declare to the MSA	FMEA	Crew Factors	Navigation or berthing Not get support and licensing information
7	Unauthorized tampering Navigation Plan	FMEA	Crew Factors	Into unfamiliar waters, increasing the collision, stranding probability
8	does Not obey VTS recommendation	FMEA	Crew Factors	Adventure Sailing
9	Passenger safety awareness	FTA	Guest factors	Smoke at No designated sites, touch devices without permit
10	Passenger overload	SLC	Guest factors	Match inadequate lifesaving equipment
11	old ship age	SLC	Passenger ship condition	Serious corrosion and oxidation, to reduce the structural strength of the hull
12	The structural strength of the hull	SLC	Passenger ship condition	

13	Passengers off on a journey equipment maintenance	SLC	Passenger ship condition	Presence gangway, passage, railings, handrails and other potentially hazardous
14	Cargo securing equipment maintenance	SLC	Passenger ship condition	The presence of bulky goods or car lashing potentially hazardous
15	Other routine maintenance	SCL	Passenger ship condition	Consumable equipment and danger in the hull structure
16	Lifesaving equipment status	FMEA	Passenger ship condition	Danger in life-saving equipment
17	Fire safety system status	SCL	Passenger ship condition	Smoke detectors, fire alarms, water mist, CO2 and other fire hazards system
18	Communication and navigation equipment guide	SCL	Passenger ship condition	AIS is Not installed, GPS and GMDSS equipment, or equipment damage unavailable
19	Pier poor location	PHA	Navigation environment	Close to the dangerous and large trucks marina
20	Pier irrational	PHA	Navigation environment	Increase the probability of the intersection of the ship from the pier and by risk
21	Pier safety facilities	PHA	Navigation environment	In case of fire life canNot be saved.
22	Hydrological & meteorological conditions	PHA	Navigation environment	Wind, current, tide and fog rain weather
23	Channel poor terrain conditions	PHA	Navigation environment	The existence of charts and NOTAM missing corners, to discuss other security risks
24	Crossing route	PHA	Navigation environment	Increasing the chance encounter ship
25	Multi-channel area construction work	PHA	Navigation environment	Increase the collision, stranding probability

26	Ship traffic flow	PHA	Navigation environment	Increasing the collision, stranding probability
27	Ship Port Density	PHA	Navigation environment	Increasing the collision, stranding probability
28	Intensive fishing period fishing season	PHA	Navigation environment	Effect passenger ship navigation
29	Rating Certificate with insufficiency	SCL	Company management	Low quality crew, poor operational level
30	Ship certificate with incomplete	SCL	Company management	Lack of SMC, DOC, NLS certificate
31	Ship duty system is Not perfect	FMEA	Company management	Inadequate lookout, appears behind schedule
32	Companies establish safety management system	FMEA	Company management	Lack of safety management system documents
33	The company did Not implement the safety management system	FMEA	Company management	Business executives ineffective implementation of DOC
34	The company did Not implement the safety management system	FMEA	Company management	Crew do Not understand or do Not perform SMC management requirements
35	Special time management	FMEA	Company management	Typhoon, cold, fishing season, major holidays and other special times for special passenger ship safety management
36	Dangerous goods management	SLC	Management of goods	Dangerous goods check is insufficient
37	Cargo Securing management	SLC	Management of goods	Cars banding robustness checks incomplete
38	Car cargo ship management	SLC	Management of	Cars banding robustness checks incomplete

			goods	
39	Cargo stowage management	SLC	Management of goods	Passenger ship stability decreased, and so did Not leave the emergency channel
40	Internal safety education	SLC	Company management	Crew safety quality decline
41	Transient traffic surge	SLC	Company management	Poor grooming, equipment is Not in place, without response options
42	On board passenger safety propaganda	SLC	Company management	Negligence, Not timely, Not in place
43	Inadequate supervision of aging passenger ships	FTA	Management of MSA	Stranded lead, collision or Bridge Collision
44	Large cruise escort aids poor	FTA	Management of MSA	Lead to maritime accidents
45	Crew competency examination, certification	FTA	Management of MSA	Not standardized, we can Not guarantee the quality of the crew
46	Shipping system audit certification	FTA	Management of MSA	Non-standard, Not strict
47	VTS is Not comprehensive monitoring	FTA	Management of MSA	Stranded lead, collision or Bridge Collision
48	VTS provides eNough information	FTA	Management of MSA	Lack of out of Hong Kong, weather, and other information channel
49	The effectiveness of the maritime sector regulatory approach	FTA	Management of MSA	Defects and deficiencies of regulation
50	Maritime sector is Not implemented strict security	FTA	Management of MSA	Lead to maritime accidents

51	Cruising the maritime sector and on-site monitoring	FTA	Management of MSA	Accident-prone area or cruise voyage is insufficient
52	Inbound and outbound visa review	FTA	Management of MSA	Crewing, ship seaworthy, passenger overcrowding and other poor conditions audit

Appendix No.2 Index weight value

Target lever	Base lever		Weights ω	Index lever	Weights ω	consistency
Shanghai maritime passenger safety comprehensive evaluation system	Human aspects	Crew factor B1	0.2030	Professional skills quality B11	0.2312	0.0039
				Safety Quality B12	0.2673	
				Physiological quality B13	0.0714	
				Psychological Quality B14	0.1295	
				Competency B15	0.3016	
		Guest factor B2	0.0309	Safety awareness B21	0.3324	0
				Passenger instantaneously surge B22	0.6676	
	The environment	Navigation safety B3	0.1212	Hydrological & meteorological conditions B31	0.2253	0.0043
				The intersection of route B32	0.3061	
				Fishing intensive job B33	0.1235	
				vessel traffic flow B34	0.2552	
				aids to navigation aids	0.0999	

				performance B35		
		Harbor security B4	0.0893	Pier site layout B41	0.6850	0
				Pier safety B42	0.3150	
	Ship respect	Ship factor B5	0.1181	Passenger ship vessel age B51	0.3500	0.0036
				The structural strength of the hull B52	0.1418	
				Ship equipment B53	0.1672	
				Boats & ship to shore communication of information B54	0.3410	
		Goods factors B6	0.0451	Cargo lashing securing B61	0.3949	0
				Inflammable and explosive dangerous goods B62	0.6051	
	Management	Internal management B7	0.2168	Crew Management B71	0.3135	0.0
				Internal safety education B72	0.2624	
				Special time management B73	0.1303	
				Establishment and operation B74 safety management system	0.2938	
		Maritime safety supervision B8	0.1756	VTS effect B81	0.2594	0.0037
				Site safety inspection B82	0.4352	
				Law enforcement personnel quality B83	0.2063	
				The effectiveness of regulation B84	0.0631	

Appendix No.3. The weight value and the estimated value of total membership

Target lever	Base lever		Weights ω		Index lever	assessment value			
						excellent	good	Medium	poor
Shanghai maritime passenger safety comprehensive evaluation system	Human aspects	Crew factor B1	0.2030	0.2312	Professional skills quality B11	0.2	0.6	0.2	0
				0.2673	Safety Quality B12	0.2	0.4	0.2	0.2
				0.0714	Physiological quality B13	0	0.6	0.2	0.2
				0.1295	Psychological Quality B14	0.6	0.4	0	0
				0.3016	Competency B15	0	0.6	0.3	0.1
		Guest factor B2	0.0309	0.3324	Safety awareness B21	0	0.6	0.4	0
				0.6676	Passenger instantaneously surge B22	0.3	0.4	0.2	0.1
	The environment	Navigation safety B3	0.1212	0.2253	Hydrological & meteorological conditions B31	0	0.3	0.6	0.1
				0.3061	The intersection of route B32	0	0.4	0.5	0.1
				0.1235	Fishing intensive job B33	0	0	0.7	0.3
				0.2552	vessel traffic flow B34	0	0.1	0.6	0.3
				0.0999	aids to navigation aids performance B35	0.7	0.3	0	0
		harbor security B4	0.0893	0.6850	Pier site layout B41	0	0.6	0.3	0.1
				0.3150	Pier safety B42	0.3	0.5	0.2	0
	Ship respect	Ship factor B5	0.1181	0.3500	Passenger ship vessel age B51	0	0.6	0.2	0.2
				0.1418	The structural strength of the hull	0.6	0.4	0	0

					B52				
				0.1672	Ship equipment B53	0.2	0.5	0.2	0.1
				0.3410	Boats & ship to shore communication of information B54	0.1	0.3	0.6	0
		Goods factors B6	0.0451	0.3949	Cargo lashing securing B61	0.6	0.4	0	0
				0.6051	Inflammable and explosive dangerous goods B62	0	0.5	0.4	0.1
	Management	Internal management B7	0.2168	0.3135	Crew Management B71	0	0.7	0.2	0.1
				0.2624	Internal safety education B72	0.1	0.8	0.1	0
				0.1303	Special time management B73	0	0.7	0.3	0
				0.2938	Establishment and operation B74 safety management system	0	0.4	0.6	0
		Maritime safety supervision B8	0.1756	0.2594	VTS effect B81	0.5	0.3	0.2	0
				0.4352	Site safety inspection B82	0.1	0.5	0.4	0
				0.2063	Law enforcement personnel quality B83	0.6	0.4	0	0
				0.0631	The effectiveness of regulation B84	0.1	0.4	0.5	0

Appendix No.4 the composite membership index

Target lever	Base lever		Weights ω		Index lever	composite membership index	Evaluation level	assessment value			
								excellent	good	Medium	poor
Shanghai maritime passenger safety comprehensive evaluation system	Human aspects	Crew factor B1	0.2030	0.2312	Professional skills quality B11	81.6	**good**	0.2	0.6	0.2	0
				0.2673	Safety Quality B12	71.2	**Medium**	0.2	0.4	0.2	0.2
				0.0714	Physiological quality B13	68.6	**Medium**	0	0.6	0.2	0.2
				0.1295	Psychological Quality B14	89.8	**good**	0.6	0.4	0	0
				0.3016	Competency B15	72.3	**Medium**	0	0.6	0.3	0.1
		Guest factor B2	0.0309	0.3324	Safety awareness B21	76	**good**	0	0.6	0.4	0
				0.6676	Passenger instantaneously surge B22	74.7	**Medium**	0.3	0.4	0.2	0.1
	The environment	Navigation safety B3	0.1212	0.2253	Hydrological & meteorological conditions B31	67.8	**Medium**	0	0.3	0.6	0.1
				0.3061	The intersection of route B32	69.3	**Medium**	0	0.4	0.5	0.1
				0.1235	Fishing intensive job B33	55.9	**poor**	0	0	0.7	0.3

				0.2552	vessel traffic flow B34	60.4	**Medium**	0	0.1	0.6	0.3
				0.0999	aids to navigation aids performance B35	91.1	**excellent**	0.7	0.3	0	0
		harbor security B4	0.0893	0.6850	Pier site layout B41	72.3	**Medium**	0	0.6	0.3	0.1
				0.3150	Pier safety B42	89.6	**good**	0.3	0.5	0.2	0
	Ship respect	Ship factor B5	0.1181	0.3500	Passenger ship vessel age B51	68.6	**Medium**	0	0.6	0.2	0.2
				0.1418	The structural strength of the hull B52	89.8	**good**	0.6	0.4	0	0
				0.1672	Ship equipment B53	76.4	**good**	0.2	0.5	0.2	0.1
				0.3410	Boats & ship to shore communication of information B54	74.9	**good**	0.1	0.3	0.6	0
		Goods factors B6	0.0451	0.3949	Cargo lashing securing B61	89.8	**good**	0.6	0.4	0	0
				0.6051	Inflammable and explosive dangerous goods B62	73	**Medium**	0	0.5	0.4	0.1
	Management	Internal	0.2168	0.3135	Crew Management	63.4	**Medium**	0	0.7	0.2	0.1

		management B7			B71						
				0.2624	Internal safety education B72	81.8	**good**	0.1	0.8	0.1	0
				0.1303	Special time management B73	77.5	**good**	0	0.7	0.3	0
				0.2938	Establishment and operation B74 safety management system	74.5	**Medium**	0	0.4	0.6	0
		Maritime safety supervision B8	0.1756	0.2594	VTS effect B81	85.5	**good**	0.5	0.3	0.2	0
				0.4352	Site safety inspection B82	77.3	**good**	0.1	0.5	0.4	0
				0.2063	Law enforcement personnel quality B83	89.8	**good**	0.6	0.4	0	0
				0.0631	The effectiveness of regulation B84	75.8	**good**	0.1	0.4	0.5	0